Asian Nursing Research 8 (2014) 293–299

Contents lists available at ScienceDirect

Asian Nursing Research

journal homepage: www.asian-nursingresearch.com

Research Article

Estimation of Effects of Factors Related to Preschooler Body Mass Index Using Quantile Regression Model

Hee Soon Kim, PhD, RN, [1] Yun Hee Park, PhD, RN, [2,*] Hyun Bong Park, MSN, RN, [2] Su Hee Kim, MSN, RN [2]

[1] College of Nursing, Nursing Policy Research Institute, Yonsei University, Seoul, South Korea
[2] College of Nursing, Yonsei University, Seoul, South Korea

ARTICLE INFO

Article history:
Received 14 November 2013
Received in revised form
9 May 2014
Accepted 23 July 2014

Keywords:
obesity
preschooler
quantile regression

SUMMARY

Purpose: The purpose of this study was to investigate Korean preschoolers' obesity-related factors through an ecological approach and to identify Korean preschoolers' obesity-related factors and the different effects of ecological variables on body mass index and its quantiles through an ecological approach.
Methods: The study design was cross-sectional. Through convenience sampling, 241 cases were collected from three kindergartens and seven nurseries in the Seoul metropolitan area and Kyunggi Province in April 2013 using self-administered questionnaires from preschoolers' mothers and homeroom teachers.
Results: Results of ordinary least square regression analysis show that mother's sedentary behavior ($p < .001$), sedentary behavior parenting ($p = .039$), healthy eating parenting ($p = .027$), physical activity −related social capital ($p = .029$) were significant factors of preschoolers' body mass index. While in the 5% body mass index distribution group, gender ($p = .031$), preference for physical activity ($p = .015$), mother's sedentary behavior parenting ($p = .032$), healthy eating parenting ($p = .005$), and teacher's sedentary behavior ($p = .037$) showed significant influences. In the 25% group, the effects of gender and preference for physical activity were no longer significant. In the 75% and 95% group, only mother's sedentary behavior showed a statistically significant influence ($p < .001$, $p = .012$ respectively).
Conclusion: Efforts to lower the obesity rate of preschoolers should focus on their environment, especially on the sedentary behavior of mothers, as mothers are the main nurturers of this age group.

Introduction

Obesity is classified as a disease, and many developed welfare states have set obesity prevention as one of their main national public health goals (World Health Organization, 2000). However, except for a few underdeveloped nations, the prevalence rate of obesity is increasing (De Onis, Blossner, & Borghi, 2010; Rokholm, Baker, & Sorensen, 2010; Stamatakis, Wardle, & Cole, 2010; Wang & Lobstein, 2006), suggesting that interventions to reduce obesity are not being effectively implemented. In Korea, one of every five preschoolers is overweight or obese, with the number steadily rising (Ministry of Health and Welfare, 2011).

Obesity in childhood not only causes disease at an early age, but may also cause children to be subjected to negative views, and thus is a major concern that calls for early intervention (Barness, Opitz, & Gilbert-Barness, 2007). An obese child can develop not only physical complications such as hyperlipidemia, fatty liver, high blood pressure, or diabetes, but also psychological and social problems, such as sense of inferiority and dissatisfaction, bullying, loss of confidence, depression, and negative body image (Erickson, Robinson, Haydel, & Killen, 2000). Therefore, obesity is a health problem that must be addressed.

Obesity at an early age often develops into teenage and adult obesity (Lloyd, Langley-Evans, & McMullen, 2012; Singh, Mulder, Twisk, Van Mechelen, & Chinapaw, 2008), and obesity over a prolonged period can cause problems due to exposure to dangerous factors related to chronic adult diseases (Reilly & Kelly, 2011). Thus, it can be cost effective with regard to public health to intervene obesity at an early age. Also, life habits formed in the preschool age often continue through the adult period (Burke, Beilin, & Dunbar, 2001; Janz, Dawson, & Mahoney, 2000), so it is desirable to promote healthy lifestyles to prevent obesity in the early period of life (Griffiths, Hawkins, Cole, & Dezateux, 2010; Livingstone, McCaffrey,

* Correspondence to: Yun Hee Park, PhD, RN, College of Nursing, Yonsei University, 50 Yonse-ro, Seodaemun-gu, Seoul, South Korea.
E-mail address: uneepak@naver.com

http://dx.doi.org/10.1016/j.anr.2014.07.005

& Rennie, 2006). Recently, obesity prevention programs have focused on preschool age children, with the ages of subjects becoming younger and younger (Lakshman et al., 2013).

For effective preschooler obesity interventions, one must consider characteristics of childhood obesity and environmental determinants affecting such factors, for example, the mother's obesity-related lifestyle behaviors, attitude, or beliefs (Kleiser, Rosario, Mensink, Prinz-Langenohl, & Kurth, 2009; Kuhl, Clifford, & Stark, 2012; Summerbell et al., 2012). Also, in order for intervention programs aimed at preschoolers to succeed, factors related to nurturing, as well as the participation of parents, must be included as key features (Summerbell et al.). Factors related to child-care facilities where preschoolers spend a significant amount of time (Benjamin et al., 2009; Ward, Vaughn, McWilliams, & Hales, 2010), as well as the regional community environment to which children belong (Weir, Etelson, & Brand, 2006), must also be considered. This is in accordance with the ecological approach which states that the environmental circumstances surrounding an individual must be considered if human factors are to be systematically understood.

Seen from this viewpoint, multi-systematic contributors are found to have an influence on childhood obesity. However, to date, there has been little research aimed to systematically determine factors related to obesity focusing on children in educational and child-care facilities (Campbell & Hesketh, 2007).

In the present study, multiple linear regression analysis or logical regression analysis was used for the statistical analyses. Multiple linear regression analysis was used with body mass index (BMI) as the dependent variable, and logistic regression analysis was used with obesity status (whether a subject was obese or not) as a dependent variable using BMI percentile. Linear regression estimates can only make statements about how factors shift the mean of the BMI distribution, whereas probit or logit estimates shed light on a particular outcome (BMI percentile > 95%) without regard to the rest of the BMI distribution (Abrevaya, 2001). These methods only explain the average value of the dependent variable and thus have the disadvantage of not being able to explain the top 95% or the bottom 5% of the group, which is the high-risk group. Also, it may be unrealistic to assume that a factor which influences the average of the dependent variable affects the rest of the distribution of BMI. On the other hand, the quantile regression approach enables researchers to better understand how various factors impact different BMI distribution quantiles (Abrevaya). This method estimates the factors for each quantile of the dependent variable, as well as its impact (Buchinsky, 1998), and is thus proposed as an appropriate method for this study. Applying an intervention in accordance with BMI level enables a differential approach, since it captures the various ways in which factors influence each of the different quantiles of BMI distribution.

In order to acquire substantive data for an effective intervention, this study aimed to investigate deciding factors related to obesity according to BMI quantile using a quantile regression model and ecological approach.

Purpose

The purpose of this study was to investigate Korean preschoolers' obesity-related factors through an ecological approach and to identify different effects of ecological variables according to BMI quantile.

Conceptual framework of this study

For a comprehensive look at related factors, an ecological model was employed as a theoretical framework (Figure 1) (McLeroy, Bibeau, Steckler, & Glanz, 1988), with diverse variables such as intrapersonal, interpersonal, organizational, and community level variables that affect preschoolers' BMIs.

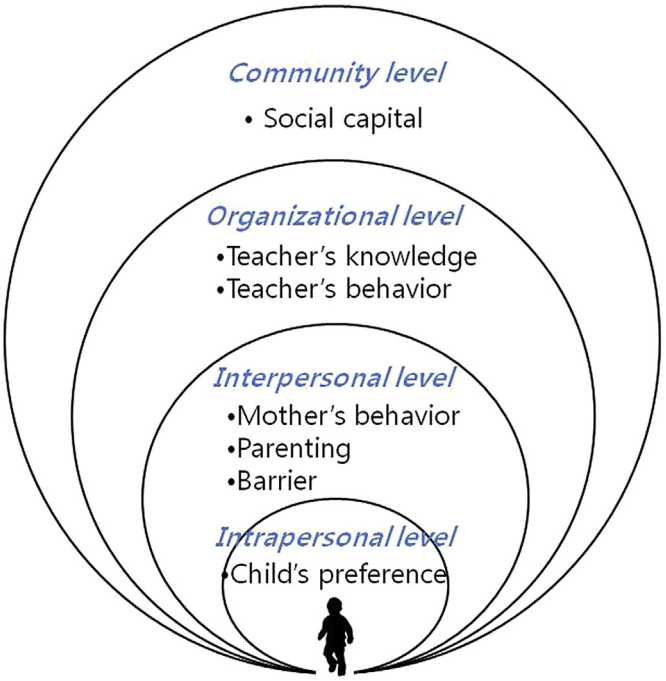

Figure 1. Conceptual framework of this study according to McLeroy's ecological model (1988).

Methods

Study design

The present study was a cross-sectional study aimed at identifying the variables which impact the BMI levels of preschoolers.

Setting and sample

The subjects of this study included 241 mothers and 20 homeroom teachers. Data were collected through convenience sampling from 10 kindergartens and nurseries in the Seoul metropolitan area and Kyunggi Province. The heads of childhood educational facilities were contacted to request their cooperation; the survey was conducted at those facilities that agreed. Study participants met inclusion criteria if they were mothers of children aged 2–5 years having no history of motor-sensory or cognitive impairment. The mother of 262 preschoolers who met the study criteria were asked to participate in the study, and 254 mothers agreed to participate. Data from 13 participants were deleted from the analysis because they missed a lot of questions. Thus, the final sample for the analysis was 241 participants. To confirm the appropriateness of the sample size in the present study, G*power 3.1.4 (Faul, Erdfelder, Lang, & Buchner, 2007), which is a method of computing sample size for multiple regression analysis, was used. The calculation applied a medium effect size of 0.15, a significance level of 5%, 95% power, and 12 predictors, resulting in a minimum sample size of 184. Thus, the appropriate sample size was secured to conduct this research.

Ethical consideration

This study was conducted after acquiring approval from the Institutional Review Board of College of Nursing, Yonsei University (IRB, College of Nursing, 2012-0018).

Measurements

Anthropometric measurements

The heights and weights of children were measured by their homeroom teachers using a GL-300 (Automatic height-weight meter, Saehan, Korea), from which BMI was calculated. In some preschools, because preexisting scheduled measurements could not take place, data acquired before March (the start of the semester), 1 month before the data collection, were used. BMI was then calculated from collected data. BMI cut-off points for each quantile set by this study were 13.63 kg/m^2 in the 5% group, 14.88 kg/m^2 in the 25% group, 16.04 kg/m^2 in the 50% group, 17.13 kg/m^2 in the 75% group, and 19.02 kg/m^2 in the 95% group. A BMI of 17.13 kg/m^2 fell in the 50–85th percentile for 2–5 year-old male and female subjects, a BMI of 19.02 kg/m^2 was equivalent to the 90–95th percentile. Therefore, the 75% group was considered as being overweight, and 95% indicated obesity.

Ecological variables

Intrapersonal level variables of preschoolers were examined by investigating the socioeconomic level of their families and their physical activity preferences. This variable set consisted of three items based on a study by Irwin, He, Bouck, Tucker, and Pollett (2005) and was scored on a 5-point Likert scale. Cronbach's alpha of this study was .71.

For the interpersonal level variable, the level of mothers' physical activity, sedentary behavior, and parenting score were measured. The physical activity level of mother was measured by survey items of the Korea National Health and Nutrition Examination Survey physical activity section, which measured walking time, mild activity time, and vigorous activity time per week (Ministry of Health and Welfare, 2011). The sedentary behaviors of mother were measured by summing the time spent viewing TV, playing video games, and using a computer. The variable of parenting was measured using the Activity Support Scale for Multiple Groups developed by Davison, Li, Baskin, Cox, and Affuso (2011). The Cronbach's alpha of this study was .72. The questionnaire for physical activity barrier and healthy eating barrier was based on the result of qualitative (Dwyer, Higgs, Hardy, & Baur, 2008) and quantitative studies (Kuhl et al., 2012) to understand the context related to physical activity and healthy eating. These questions consisted of nine items rated on a 5-point Likert scale and its Cronbach's alpha in this study was .69.

For the organizational level variables, the level of knowledge related to obesity possessed by homeroom teachers and the physical activity and sedentary behavior levels of teacher were measured. Knowledge related to obesity was measured by the Tool to Measure Knowledge Related to Childhood Obesity of Daycare Center Workers instrument (Lee & Yang, 2011). This consisted of 30 items measured on a true or false scale. The Cronbach's alpha was .68.

For the community level variables, the physical activity–related social capital of the region in which the child resides, was measured by a questionnaire based on research on the physical activity–related environment (Carver, Timperio, & Crawford, 2008). These measures consisted of eight items scored on a 4-point Likert scale and the Cronbach's alpha was .76.

Procedures

The data were collected over a 1-month period in April 2013. The questionnaire was answered by the children's mothers. Physical activity, sedentary behavior, and parenting levels of mothers were measured by self-administered questionnaires. The organizational variable was measured by homeroom teachers' answers to self-administered questionnaires.

The questionnaires were completed at kindergartens (two kindergartens connected to elementary schools and one private nursery). Homeroom teachers delivered the questionnaires to preschoolers' mothers after obtaining written informed consent and describing the survey process to them. If the mothers had any question, they contacted the researcher directly by phone.

Data analysis

For the data analysis, SPSS version 20.0 (IBM SPSS Statistics, Chicago, IL, USA) was used to conduct descriptive statistics and bivariate analysis on the baseline data. Through Pearson's correlation coefficient, variables which were in a significant relationship to the children's BMIs were determined. The dependent variable was set as the status of obesity, Student's t test or chi-square test was conducted to confirm the statistically significant variables. Then, the variables to be included in the final regression model were determined. In addition, variables which were statistically significant in the ordinary least square (OLS) regression model were added to the final model. Even if just one of the variables related to parenting and barriers was significant, all of the parenting and barrier variables were included in the final model. In addition, based on the aforementioned studies, major variables that must be considered according to the ecological model were also included into the final model. The effects of independent variables on quantile regression can differ from existing methods, so as many variables as possible were included in the final model.

Using STATA software package, version 13 (STATA, College Station, Texas), simultaneous quantile regression analysis was conducted. The number of bootstrapping size was 20, and it was used to estimate standard error of the estimates. In the distribution of BMI, the dependent variable was divided into quantiles of 5%, 25%, 50%, 75%, and 95%. Variables with significant effect were confirmed for each quantile.

Results

Descriptive statistics of ecological variables

The average age of the preschool subjects was 51.13 months old (± 14.39 months), and 70% of families earned more than KRW 3,000,000 a month on average. The average BMI was 16.12 kg/m^2; 186 of the children (77.2%) had an average weight; 29 (12.0%) were overweight; 26 (10.8%) were obese.

The mean age of mothers was 35.52 years (± 3.44 years). Over 60% were housewives, and about 80% were college graduates. Table 1 shows the average physical activity and sedentary behavior levels of mothers, obesity-related parenting, and barrier score out of 100. Of the total subjects, 121 children (50.2%) attended kindergarten and 120 (49.8%) attended a nursery. In the present study, three kindergartens and seven nurseries were investigated. The mean age for homeroom teachers was 34.32 years (± 6.34 years), the average career length was 9.18 years (± 6.74 years) and average walking time per week was 4.16 hours (± 6.01 hours), which was similar to that of the mothers. However, the subjects showed lower levels of mild and vigorous activity. Physical activity–related social capital was on average 60 on a scale of 100 (not presented by table).

Bivariate and OLS regression analyses of correlates of preschoolers' BMIs

Variables that showed a significant influence on preschoolers' BMIs were the mother's sedentary behavior, physical activity

Table 1 *Ecological Variables and Preschoolers' BMI.*

Ecological variables		*n* (%)	*M* ± *SD*	*t* or *F*	*p*
Intrapersonal level	Age (months)		51.13 ± 14.39	−0.019[a]	.765
	Gender				
	Male	115 (47.7)	16.12 ± 1.72	0.002	.964
	Female	126 (52.3)	16.11 ± 1.94		
	Income (million KRW)				
	< 3	71 (29.5)	15.99 ± 1.47	0.357	.700
	3–6	113 (46.9)	16.12 ± 2.12		
	> 6	57 (23.7)	16.26 ± 1.63		
	Preference for PA		76.31 ± 18.05	0.036[a]	.576
Interpersonal level	Mother's PA				
	Walking (hour)		4.25 ± 3.84	0.008[a]	.898
	MA (hour)		1.82 ± 2.55	−0.202[a]	.763
	VA (hour)		1.09 ± 2.64	−0.053[a]	.413
	Mother's SB (hour)		9.15 ± 6.56	0.259[a]	<.001
	Mother's parenting				
	PA parenting		58.27 ± 13.97	−0.159[a]	.014
	SB parenting		83.71 ± 19.88	−0.116[a]	.074
	HE parenting		68.73 ± 15.50	0.052[a]	.423
	Barriers				
	PA barrier		42.55 ± 16.09	0.066[a]	.311
	HE barrier		43.86 ± 14.51	0.058[a]	.367
Organizational level	Teacher's knowledge		18.61 ± 3.59	−0.028[a]	.660
	Teacher's PA				
	Walking (hour)		4.16 ± 6.01	−0.006[a]	.922
	MA (minute)		0.68 ± 0.57	−0.030[a]	.648
	VA (minute)		0.40 ± 0.76	−0.029[a]	.650
	Teacher's SB (hour)		9.37 ± 3.21	0.114[a]	.078
Community level	PA-related social capital		59.79 ± 14.60	−0.205[a]	.001

Note. PA = physical activity; SB = sedentary behavior; HE = healthy eating; MA = mild activity; VA = vigorous activity.
[a] Pearson's correlation coefficient.

Table 2 *Comparison of OLS and Quantile Regression for Effect of Ecological Variables on Preschoolers' BMI*

Variable	Quantile regression result					OLS
	q5	q25	q50	q75	q95	
Intrapersonal level						
Age	−0.04	−0.15	−0.01	−0.01	0.28	−0.06
Gender	0.91*	−0.29	−0.25	−0.10	−0.06	−0.15
Preference for PA	−0.12*	−0.01	0.05	0.13	0.14	0.03
Interpersonal level						
Mother's SB	0.05	0.04	0.06**	0.07***	0.16*	0.07***
PA parenting	−0.15	−0.04	−0.04	−0.01	−0.13	−0.09
SB parenting	−0.20*	−0.18**	−0.13	−0.09	−0.06	−0.12*
HE parenting	0.10**	0.06	0.07**	0.04	0.01	0.07*
PA barrier	−0.06	−0.02	0.01	0.05	0.07	−0.01
HE barrier	0.04	0.03	0.05	0.01	−0.11	0.04
Organizational level						
Teacher's knowledge	−0.01	0.01	0.01	−0.04	−0.05	−0.01
Teacher's SB	0.16*	0.13**	0.10**	0.03	−0.01	0.06
Community level						
PA-related social capital	−0.05	−0.05	−0.09*	−0.09	−0.12	−0.08*
Constant	14.05***	15.99***	15.44***	16.83***	20.65***	16.73***
R^2	.16	.11	.11	.12	.18	.15

Note. OLS = ordinary least square; BMI = body mass index; PA = physical activity; SB = sedentary behavior; HE = healthy eating.
*$p < .05$. **$p < .01$. ***$p < .001$.

parenting, and physical activity–related social capital (Table 1). According to OLS regression analysis conducted with BMI as the dependent variable, mother's sedentary behavior ($p < .001$), sedentary behavior parenting ($p = .039$), healthy eating parenting ($p = .027$) and physical activity–related social capital ($p = .029$) showed significant effects on preschoolers' BMIs (Table 2). However, when bivariate analysis was conducted with the dependent variable set as the variable that divided the normal and obese group, teacher's sedentary behavior ($p = .015$), physical activity parenting ($p = .006$), healthy eating barrier ($p = .040$), and age ($p < .001$) showed significant differences. In addition, when all variables were included in logistic regression analysis, the results showed that mother's sedentary behavior (odds ratio [OR] = 1.01, $p < .001$), healthy eating parenting (OR = 1.11, $p = .047$), teacher's sedentary behavior (OR = 1.01, $p = .038$), and child's age (OR = 1.91, $p = .002$) were significant.

Comparison of OLS and quantile regression analysis for effect of ecological variables on preschoolers' BMI

In OLS regression analysis, mother's sedentary behavior ($p < .001$), sedentary behavior parenting ($p = .039$), healthy eating parenting ($p = .027$), physical activity–related social capital ($p = .029$) were significant factors of preschoolers' BMI. While in the 5% group of the BMI distribution, gender ($p = .031$), preference for physical activity ($p = .015$), sedentary behavior parenting ($p = .032$), healthy eating parenting ($p = .005$), and teacher's sedentary behavior ($p = .037$) showed significant influences. In the 25% BMI group, the effects of gender, preference for physical activity and healthy eating parenting were no longer significant. In the 50% group, mother's sedentary behavior ($p = .001$), healthy eating parenting ($p = .004$), teacher's sedentary behavior ($p = .001$) and physical activity–related social capital ($p = .024$) revealed significant influences. In the 75% and 95% group, only the mother's sedentary behavior showed a statistically significant influence ($p < .001$, $p = .012$, respectively).

Discussion

As expected, factors differently affected subjects in each BMI percentile. Only in the 5% group, preference for physical activity had a significant influence, whereas in the 5%, 25%, and 50% groups, the effects of major environmental agency, such as mothers' and teachers' sedentary behavior, were shown to be significant. However, in the 75% and 95% group, only the mothers' sedentary behavior showed a significant influence. Preschoolers have not yet formulated habits or behavioral patterns in general, so the main environmental agent, such as parenting or behaviors set by mothers or teachers, was confirmed to have a major influence on the health outcome of children in this age group.

Preference for physical activity can have an influence on children's activity level. However, parents with children who prefer physical activity find it easier to get them to participate in physical activity, whereas for children who prefer sedentary activities, such as reading or watching TV, their mothers must exert comparatively more effort for their children to be physically active (Irwin et al., 2005). As such, physical activity preference has the possibility of positively influencing the nurturing of mothers. This can be inferred from the simultaneous significant effects of the parenting practices of mothers and preference for physical activity in the group with the lowest BMI.

The health-related behaviors of preschoolers are under the influence and control of mothers (Irwin et al., 2005). As such, mothers' parenting practices heavily influence children's health problems in the early period, as in the case of preschoolers. This is especially so in the period of developing personal habits, when the environment provided by the key nurturers forms not only childhood habits, but habits that affect lifetime health; thus, this time of

life is very significant with regard to future health (Burke et al., 2001; Janz et al., 2000).

According to the results of the present study, the children in the 5%, 25%, and 50% BMI groups were significantly influenced by their mothers' increasing practices of limiting sedentary behavior—BMI was reduced. As healthy eating practices increased, BMI increased. In the nonobese group with a BMI less than 50%, parenting practices in support of healthy eating may have positively contributed to maintaining healthy weight. However, parenting that limits sedentary behavior can encourage children to become active, thus reducing BMI.

The effects of physical activity and healthy eating barriers were not significant in any quantile. All of these variables were scored 50 of 100, with no mean + 1 standard deviation above 60 (physical activity barrier score 58.4 and healthy eating barrier score 58.6). Comparing the results of the present study with that of a study by Jacobson Vann et al. (2011), only the score of the obstacle "lack of time to prepare healthy food" was shown to be higher in the present study (11.3% vs. 24.9%). All other items showed a lower score than other studies, including the cost (41.7% vs. 35.7%), preference for healthy food (36.5% vs. 18.3%), eating in front of TV or computer (49.5% vs. 32.4%), lack of time to play (50.8% vs. 39.0%), and cost and time to participate in sports programs (41.7% vs. 20.8%). In Korea, large markets, sports centers, culture centers (schools of extended education), and other such facilities are located in most regions. In addition, private education includes active diverse physical activity programs in many facilities, as well as shuttle buses to those facilities, so this result is not irrelevant to the fact that access to healthy food and physical activity programs is very high. Also, mothers encourage their children to participate in physical activity programs, which may mitigate their lack of time to cook healthy food when they have jobs, although more than 60% of them were full-time housewives. Therefore, it is possible that the effect of barriers was not significant in this study. Further studies are needed comparing mothers with and without jobs. Also, if a child's main nurturer is not the mother, the nurturing environment is different, and therefore the effects of obesity-related factors and health need to be compared and analyzed with regard to these environmental differences.

Over 85% of Korean children in the preschool age period (aged 2–5 years) attend educational and nursery facilities (Ministry of Health and Welfare, 2012). Variation in children's physical activity is more increased by institutional factors (organizational level) than by sociodemographic characteristics (individual level) (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). Therefore, consideration of the influence of organizational level among all obesity-related factors is necessary to determine the substantive determinants of obesity. Children attending nursery institutions have a higher possibility of becoming overweight or obese compared to children nurtured at home. This is because caregivers in these facilities have lower rates of recommending healthy eating or encouraging physical activity in comparison to those of parents (Benjamin et al., 2009). This result shows the appropriateness of interventions to provide teachers and administrators of education and nursery facilities with professional knowledge related to health. A teacher with sufficient knowledge about obesity can play a role in encouraging physical activity in children, thereby reducing childhood obesity (National Association for Sport and Physical Education, 2002). In fact, research has shown that, when teachers received obesity-related education, the rate of overweight or obese children was significantly lower (Ratanachu-ek & Moungnoi, 2008). However, in the present study, knowledge of obesity by homeroom teachers did not significantly affect children's BMIs. This result may reflect the nature of the Korean educational system in which the policy-making process is dominated by the kindergarten or nursery administrator, not the homeroom teachers; class is not run at the discretion of homeroom teachers, but by administrators. Further studies are needed to collect data on the principals of these facilities and the ways in which they run physical activity programs. These differences should then be analyzed in terms of children's BMI. In other words, examining the effort that facilities put into obesity prevention education, physical activity subjects, and recreation may reveal important implications stemming from the environment in Korea, where there are few obesity education materials provided to teachers or obesity-related programs targeted at children.

The optimal guidelines for nurturing children between the ages of 2–3 years recommend 60–90 minutes of outdoor activities every day (American Academy of Pediatrics, American Public Health Association, & National Resource Center for Health and Safety in Child Care and Early Education, 2011). However, some parents do not think it is safe for children to play (Irwin et al., 2005). They may have concerns about traffic, high crime rate, or a lack of traffic lights or crosswalks. This prevents parents from recommending outdoor activities without anxiety, and therefore this becomes a barrier. In addition, the safety of a neighborhood can also be a barrier to physical activity (Weir et al., 2006). In the present study, the physical activity–related social capital variable had a significant effect in the 50% BMI group but not in the high BMI group. The OLS analysis results showed the physical activity–related social capital variable to be significant ($p = .029$), and this research raises the possibility that the residential environment of the child affects obesity.

Obesity is determined by BMI-related factors in the high BMI group. According to the present study, in the groups with high BMI (75% and 95%), the factor that was significant in its effect on BMI was mother's sedentary behavior. This indicates a close relationship between the activity patterns of parents and children (Ritchie et al., 2001). In these percentile groups, the parenting of mothers and influence of teachers no longer showed any impact. The parenting and behavior of mothers are sometimes inconsistent. In other words, most mothers have good intentions when parenting their children but may not be practicing healthy behaviors themselves. This is because practicing and sustaining healthy behaviors such as physical activity can be very difficult (Coday et al., 2002).

Many seemingly effective and efficient obesity intervention studies aiming to modify lifestyle behaviors of patients have experienced more failure than success. This indicates the difficulty in modifying human behavior. This result shows that the focus of childhood obesity interventions should be on the most common environmental agent, especially on the behavior of mothers.

Quantile regression analysis enabled the identification of the differential effects of key variables related to childhood obesity according to BMI distribution. As this is not a longitudinal study, BMI increase cannot be observed. We suggest changing this to "the mother's sedentary behavior as one of interpersonal level variable identified as more effective for higher BMI group". On the other hand, the sedentary behavior of teachers, which is a variable at the organizational level, and the physical activity–related social capital variable, which is a community level variable, decreased in effect as BMI increased (Figure 2). This showed that, as BMI increases, interventions should be focused on interpersonal level variables. Therefore, in childhood obesity interventions, as obesity becomes more severe, interpersonal level variables should be prioritized.

One of the limitations of this study is to get the study sample from the three kindergartens and seven nurseries. Multiple kids from the same kindergarten or nursery may create the possibilities of cluster effect that can make an underestimation of standard errors and high probability of type one error. To correct the cluster effects in the estimation, either robust standard error estimation or

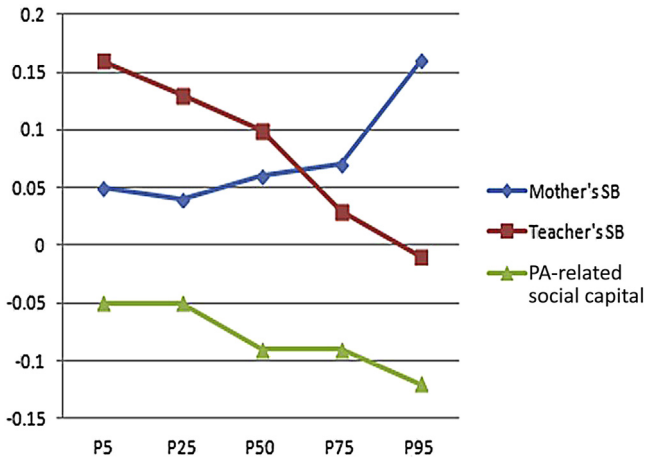

Figure 2. Estimated body mass index curve according to quantile regression. *Note.* SB = sedentary behavior; PA = physical activity.

mixed effect model can help control this effect. Another one is not including the characteristics of the agency. There might be organizational factor that play important roles in explaining BMI levels. Lastly, the several instruments used in this study were not examined and validated for the study population.

Conclusion

The present study attempted to systematically identify the determinants of obesity in children during the preschool age period, which has not been received much attention. In particular, this study employed a unique statistical method that can track the effects of contributing factors in each BMI quantile to identify the effect of each variable by group. This enabled the acquisition of baseline data making specific intervention approaches possible in the at-risk population.

In the present study, the obesity of preschoolers had experienced the different effects of contributing factors on obesity. In the high BMI group in particular, mothers' sedentary behavior has a significant effect. This suggests that interventions targeting obesity in preschoolers should focus on the environment surrounding children, especially on the sedentary behavior of mothers, as they are the main nurturers of children.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

Funding for this study was provided by a grant to the faculty research program from the Nursing Policy Research Institute, Yonsei University College of Nursing.

References

Abrevaya, J. (2001). The effect of demographic and maternal behavior on the distribution of birth outcomes. *Empirical Economics, 26*(1), 247–257.

American Academy of Pediatrics, American Public Health Association, and National Resource Center for Health and Safety in Child Care and Early Education. (2011). *Caring for our children: National health and safety performance standards; Guidelines for early care and education programs*. Elk Grove Village, IL: American Academy of Pediatrics (3rd ed.). Washington, DC: American Public Health Association. Retrieved October 22, 2013, from http://cfoc.nrckids.org/WebFiles/CFOC3_Book_6-10-14Update_.pdf

Barness, L. A., Opitz, J. M., & Gilbert-Barness, E. (2007). Obesity: genetic, molecular, and environmental aspects. *American Journal of Medical Genetics Part A, 143A*(24), 3016–3034. http://dx.doi.org/10.1002/ajmg.a.32035

Benjamin, S. E., Rifas-Shiman, S. L., Taveras, E. M., Haines, J., Finkelstein, J., Kleinman, K., et al. (2009). Early child care and adiposity at ages 1 and 3 years. *Pediatrics, 124*(2), 555–562. http://dx.doi.org/10.1542/peds.2008-2857

Buchinsky, M. (1998). Recent advances in quantile regression models: a practical guideline for empirical research. *Journal of Human Resources, 33*, 88–126.

Burke, V., Beilin, L. J., & Dunbar, D. (2001). Family lifestyle and parental body mass index as predictors of body mass index in Australian children: a longitudinal study. *International of Journal of Obesity, 25*(2), 147–157. http://dx.doi.org/10.1038/sj.ijo.0801538

Campbell, K. J., & Hesketh, K. D. (2007). Strategies which aim to positively impact on weight, physical activity, diet and sedentary behaviours in children from zero to five years. A systematic review of the literature. *Obesity Reviews, 8*(4), 327–338. http://dx.doi.org/10.1111/j.1467-789X.2006.00305.x

Carver, A., Timperio, A., & Crawford, D. (2008). Playing it safe: the influence of neighbourhood safety on children's physical activity. A review. *Health and Place, 14*(2), 217–227. http://dx.doi.org/10.1016/j.healthplace.2007.06.004

Coday, M., Klesges, L. M., Garrison, R. J., Johnson, K. C., O'Toole, M., & Morris, G. S. (2002). Health Opportunities with Physical Exercise (HOPE): social contextual interventions to reduce sedentary behavior in urban settings. *Health Education Research, 17*(5), 637–647.

Davison, K. K., Li, K., Baskin, M. L., Cox, T., & Affuso, O. (2011). Measuring parental support for children's physical activity in white and African American parents: the Activity Support Scale for Multiple Groups (ACTS-MG). *Preventive Medicine, 52*(1), 39–43. http://dx.doi.org/10.1016/j.ypmed.2010.11.008

De Onis, M., Blossner, M., & Borghi, E. (2010). Global prevalence and trends of overweight and obesity among preschool children. *The American Journal of Clinical Nutrition, 92*(5), 1257–1264. http://dx.doi.org/10.3945/ajcn.2010.29786

Dwyer, G. M., Higgs, J., Hardy, L. L., & Baur, L. A. (2008). What do parents and preschool staff tell us about young children's physical activity: a qualitative study. *International Journal of Behavior Nutrition and Physical Activity, 5*(1), 66. http://dx.doi.org/10.1186/1479-5868-5–66

Erickson, S. J., Robinson, T. N., Haydel, K. F., & Killen, J. D. (2000). Are overweight children unhappy? Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Archives of Pediatrics and Adolescent Medicine, 154*(9), 931–935. http://dx.doi.org/10.1001/archpedi.154.9.931

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. http://dx.doi.org/10.3758/BF03193146

Griffiths, L. J., Hawkins, S. S., Cole, T. J., & Dezateux, C. (2010). Risk factors for rapid weight gain in preschool children: findings from a UK-wide prospective study. *International Journal of Obesity, 34*(4), 624–632. http://dx.doi.org/10.1038/ijo.2010.10

Irwin, J. D., He, M., Bouck, L. M. S., Tucker, P., & Pollett, G. L. (2005). Preschoolers' physical activity behaviours: parents' perspectives. *Canadian Journal of Public Health, 96*(4), 299–303.

Jacobson Vann, J. C., Finkle, J., Ammerman, A., Wegner, S., Skinner, A. C., Benjamin, J. T., et al. (2011). Use of a tool to determine perceived barriers to children's healthy eating and physical activity and relationships to health behaviors. *Journal of Pediatric Nursing, 26*(5), 404–415. http://dx.doi.org/10.1016/j.pedn.2010.10.011

Janz, K. F., Dawson, J. D., & Mahoney, L. T. (2000). Tracking physical fitness and physical activity from childhood to adolescence: The Muscatine study. *Medicine and Science in Sports and Exercise, 32*(7), 1250–1257.

Kleiser, C., Rosario, A. S., Mensink, G. B. M., Prinz-Langenohl, R., & Kurth, B. M. (2009). Potential determinants of obesity among children and adolescents in Germany: results from the cross-sectional KiGGS study. *BMC Public Health, 9*(1), 46. http://dx.doi.org/10.1186/1471-2458-9-46

Kuhl, E. S., Clifford, L. M., & Stark, L. J. (2012). Obesity in preschoolers: behavioral correlates and directions for treatment. *Obesity, 20*(1), 3–29. http://dx.doi.org/10.1038/oby.2011.201

Lakshman, R., Paes, V. M., Hesketh, K., O'Malley, C., Moore, H., Ong, K., et al. (2013). Protocol for systematic reviews of determinants/correlates of obesity-related dietary and physical activity behaviors in young children (preschool 0 to 6 years): evidence mapping and syntheses. *Systematic Review, 2*(1), 28. http://dx.doi.org/10.1186/2046-4053-2-28

Lee, D. J., & Yang, Y. O. (2011). Knowledge related to child obesity of child daycare center worker. *Journal of Korean Academy of Child Health Nursing, 17*(4), 247–255.

Livingstone, M. B. E., McCaffrey, T. A., & Rennie, K. L. (2006). Childhood obesity prevention studies: lessons learned and to be learned. *Public Health Nutrition, 9*(8A), 1121–1129. http://dx.doi.org/10.1017/s1368980007668505.

Lloyd, L. J., Langley-Evans, S. C., & McMullen, S. (2012). Childhood obesity and risk of the adult metabolic syndrome: a systematic review. *International Journal of Obesity, 36*(1), 1–11. http://dx.doi.org/10.1038/ijo.2011.186

McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education and Behavior, 15*(4), 351–377. http://dx.doi.org/10.1177/109019818801500401

Ministry of Health and Welfare. (2011). *Korea health statistics 2010: Korea National Health and Nutrition Examination Survey (KNHANES-1)*. Seoul: Author.

Ministry of Health and Welfare. (2012). *Statistics for nurture and child*. Seoul: Author. Retrieved October 22, 2013, from http://stat.mw.go.kr/front/statData/publicationView.jsp?menuId=40&bbsSeq=6&nttSeq=20639&searchKey=&searchWord=&nPage=2

National Association for Sport and Physical Education. (2002). *Active start: A statement of physical activity guidelines for children birth to five years*. Reston, VA: Author.

Pate, R. R., Pfeiffer, K. A., Trost, S. G., Ziegler, P., & Dowda, M. (2004). Physical activity among children attending preschools. *Pediatrics, 114*(5), 1258–1263. http://dx.doi.org/10.1542/peds.2003-1088-L

Ratanachu-ek, S., & Moungnoi, P. (2008). The effect of teacher education on the prevalence of obesity in kindergarten children. *Journal of the Medical Association of Thailand, 91*(Suppl. 3), S152–156.

Reilly, J. J., & Kelly, J. (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *International Journal of Obesity, 35*(7), 891–898. http://dx.doi.org/10.1038/ijo.2010.222

Ritchie, L. D., Ivey, S., Masch, M., Woodward-Lopez, G., Ikeda, J., & Crawford, P. (2001). *Pediatric overweight: A review of the literature*. Berkley, CA: The Center for Weight and Health at University of California.

Rokholm, B., Baker, J. L., & Sorensen, T. I. A. (2010). The levelling off of the obesity epidemic since the year 1999—A review of evidence and perspectives. *Obesity Reviews, 11*(12), 835–846. http://dx.doi.org/10.1111/j.1467-789X.2010.00810.x

Singh, A. S., Mulder, C., Twisk, J. W. R., Van Mechelen, W., & Chinapaw, M. J. (2008). Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obesity Reviews, 9*(5), 474–488. http://dx.doi.org/10.1111/j.1467-789X.2008.00475.x

Stamatakis, E., Wardle, J., & Cole, T. J. (2010). Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *International Journal of Obesity, 34*(1), 41–47. http://dx.doi.org/10.1038/ijo.2009.217

Summerbell, C. D., Moore, H. J., Vogele, C., Kreichauf, S., Wildgruber, A., Manios, Y., et al. (2012). Evidence-based recommendations for the development of obesity prevention programs targeted at preschool children. *Obesity Reviews, 13*(Suppl. 1), 129–132. http://dx.doi.org/10.1111/j.1467-789X.2011.00940.x

Wang, Y., & Lobstein, T. (2006). Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity, 1*(1), 11–25.

Ward, D. S., Vaughn, A., McWilliams, C., & Hales, D. (2010). Interventions for increasing physical activity at child care. *Medicine and Science in Sports and Exercise, 42*(3), 526–534. http://dx.doi.org/10.1249/MSS.0b013e3181cea406

Weir, L. A., Etelson, D., & Brand, D. A. (2006). Parents' perceptions of neighborhood safety and children's physical activity. *Preventive Medicine, 43*(3), 212–217. http://dx.doi.org/10.1016/j.ypmed.2006.03.024

World Health Organization. (2000). Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. *WHO Technical Report Series, 894*.